Yield Improvement of Optical Fiber Manufacturing through Redesign of ACVD Burner

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Abstract— A burner design has been proposed to improve the manufacturing yield of optical fiber. The burner is an important device to fabricate the soot preforms in ACVD process which leads to draw optical fiber in subsequent manufacturing process. The glass formation at the tip of burner fumes tube is a common defect which leads to scrap soot preform. The burner has been redesigned using Computational Fluid Dynamics (CFD) simulation software to understand the interaction of silica precursor, hydrogen and oxygen gas flow paths and to avoid glass formation.

1. INTRODUCTION

The ACVD is a well-known technology for manufacturing of glass performs used for drawing optical fibers. A burner is an important device in ACVD manufacturing process and it is used for formation of silica particles from combustion of hydrogen, oxygen and silica precursors. Silica particles hence produced are deposited on a bait/glass rod in the form of soot preform. There are many technical papers published on theoretical calculation in ACVD technology and a couple of them have been discussed below. Fundamental understanding of soot deposition with process optimization has been discussed by Pushkar Tandon [1]. The variation of soot temperature with time is presented in the work. Modeling of the flame temperature with different steps of chemical reaction has been discussed by Hannebauer et al. [2]. It is also understood from the literature survey that the defects will generate during the soot preform fabrication if the burner is not designed correctly.

There are many defects such as glass formation at burner tip, wart on soot preform and bad interface on soot preform in the ACVD process which leads to scrap soot preform. The overall manufacturing cost of optical fiber increases if the soot preform is scrapped. It has been a challenging task to decrease the optical fiber manufacturing cost due to current competitive market. To understand and remove the defects, engineers explore to use of smart engineering tools which is a cost effective solution. The Computational Fluid Dynamics (CFD) simulation software has been used to understand the defect, known as glass formation at the tip of burner.

The article presents a CFD calculation of interaction of gas flow paths of silica precursor, hydrogen and oxygen in the generic and redesigned burners. In this study, the gas velocities resulted from CFD calculation have been discussed.

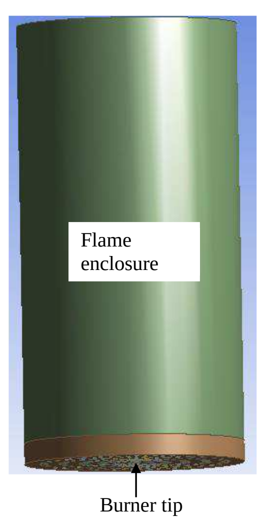

Figure 1: 3D drawing of generic burner.

2. THEORETICAL CALCULATION

ANSYS FLUENT [3] software is used to solve the governing equations, which is a finite volume method (FVM) based CFD code. As part of the CFD calculation, the 3D engineering drawings of the both generic and redesigned burners are prepared (as shown in Figure 1). A good quality mesh is generated in the 3D drawings (as shown in Figure 2). The governing equations of mass conservation, Navier-Stokes, turbulence and species transport are solved to find out the velocity profile of gases at the burner tip.

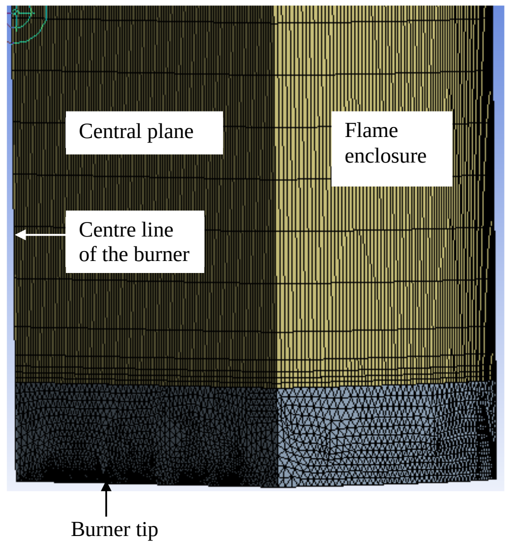

Figure 2: Mesh in a section of the generic burner.

3. RESULTS

The velocity vectors are shown in Figure 3 for both burners as part of CFD results. Figures 3(a) and 3(b) represent for generic and redesigned burners respectively.

The axis shown in Figure 3 represents for fumes tube of burners. The pitch circle diameters of redesigned burner are decreased by 4 units as compared to the generic burner keeping all other inputs constant. The gas injection locations are marked in arrow.

The velocity field causes for glass formation at the tip of fumes tube in the generic burner due to less gas flow between first and second injections and a recirculation zone between second and third injections (Figure 3(a)). Whereas the velocity field generated in the redesigned burner doesn't allow for glass formation as the gas flows are directed towards the first and second injections from the second and third injections respectively (Figure 3(b)).

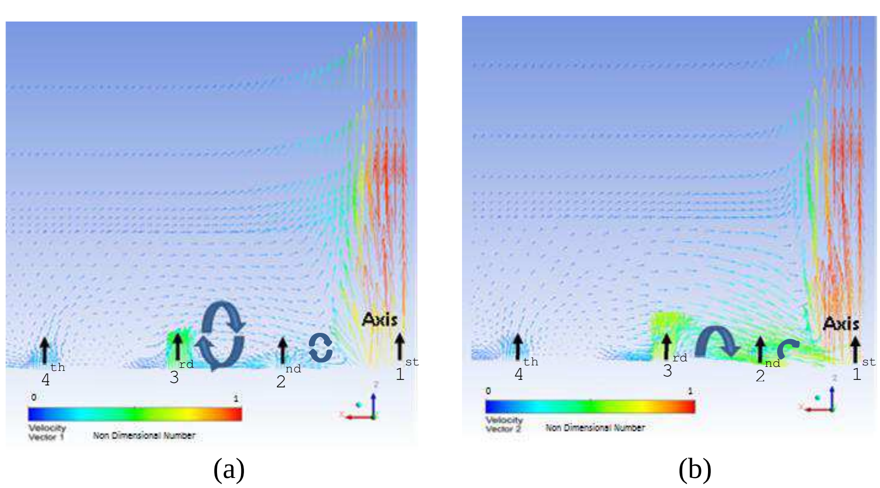

Figure 3: Non-dimensional velocity vectors: (a) generic burner, (b) redesigned burner.

4. CONCLUSIONS

A burner of the ACVD based optical fiber manufacturing technology has been redesigned to lower the scrap of soot preform. Computational Fluid Dynamics (CFD) simulation software was used to compare the gas flow interaction at the tip of generic and redesigned burners. The governing equations of mass conservation, Naiver-Stokes, turbulence and species transport are solved in the CFD calculation. It is understood from the gas velocity field that the recirculation zone is observed in the general burner and the glass formation is found at the burner tip. The recirculation zone is not observed in the redesigned burner.

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